

## CLAIMS

We claim:

1. An orthodontic treatment planning workstation comprising a computing platform having a graphical user interface, a processor and a computer storage medium containing digitized records pertaining to a patient, said digitized records including image data, text data, and a set of software instructions providing graphical user interface tools for providing a user with access to said digitized records for planning orthodontic treatment of a patient, wherein said set of instructions include:
  - a) treatment plan instructions providing graphical user interface tools for allowing said user to interactively create a proposed set-up for treatment of the patient, the proposed set-up comprising a proposed three-dimensional position of the dentition and the surrounding craniofacial structure; and
  - b) evaluation instructions providing a series of predetermined steps for guiding a user to interactively evaluate said proposed set-up, wherein the predetermined steps comprise steps for 1) evaluation of said proposed set-up against boundary conditions for treatment of the patient, the boundary conditions including at least a midline, an occlusal plane, a fixed reference object, and an arch form, and 2) evaluation of whether the tooth positions in both arches, and the inter-arch relationship, of the proposed set-up correspond to the treatment goals for the patient.
2. The workstation of claim 1, wherein the evaluation instructions further comprise instructions which allow a user to modify the proposed set-up during one or more of said predetermined steps, and wherein modifications made in any one of said one or more

predetermined steps are carried over to subsequent steps in said series of predetermined steps.

3. The workstation of claim 1, wherein said evaluation instructions further comprise instructions which allow a user to navigate through said series of predetermined steps in any order desired by the user.

4. The workstation of claim 1, wherein the evaluation instructions further comprise instructions which allow a user to compare the position of the teeth in the proposed set-up to associated bone and soft tissue in the craniofacial complex.

5. The workstation of claim 1, wherein said series of predetermined steps comprise the following evaluation steps of the proposed set-up:

1. checking said midline, said occlusal plane and reference objects, if any;
2. checking the lower arch form and the anterior/posterior (AP) positions of teeth in the lower arch;
3. checking the upper arch form and the AP position of the teeth in the upper arch;
4. checking the overbite and overjet;
5. checking intra-arch tooth alignment;
6. checking intra-arch tooth positions, rotations, contact points, marginal ridges, cusp tips, central grooves and cusp-fossa relations;
7. checking the torque values of at least some of the teeth of the upper and lower arches;
8. checking bite registration;
9. checking gingival architecture;

10. checking functional contact points; and
11. checking axial inclination of teeth.

6. The workstation of claim 5, wherein said evaluation instructions are designed to guide a user to follow steps 1-11 in numerical order, while simultaneously providing the user to navigate from any one of said steps to any other of said steps.

7. The workstation of claim 7, wherein step 4 further comprises instructions for allowing a user to check an occlusion class of said proposed set-up.

8. A computerized method of planning treatment for an orthodontic patient, comprising the steps of:

providing an orthodontic treatment planning workstation comprising a computing platform having a graphical user interface, a processor and a computer storage medium containing digitized records pertaining to a patient, said digitized records including image data, and a set of software instructions providing graphical user interface tools for providing a user with access to said digitized records and for planning orthodontic treatment of a patient;

generating a proposed set-up for treating the patient, the proposed set-up comprising a proposed three-dimensional position of the dentition and surrounding craniofacial structure of the patient in a post-treatment condition;

conducting an evaluation of said proposed set-up, said evaluation prompted by computer instructions providing a series of predetermined steps for guiding a user to interactively evaluate said proposed set-up, wherein the predetermined steps comprise steps

for 1) evaluation of said proposed set-up against boundary conditions for treatment of the patient, the boundary conditions including at least a midline, an occlusal plane, a fixed reference object and an arch form, and 2) evaluation of whether the tooth positions in both arches, and the inter-arch relationship, of the proposed set-up correspond to the treatment goals of the patient.

9. The method of claim 8, wherein said computer instructions are loaded on said workstation and said evaluation is thereby performed by a user using said workstation.

10. The method of claim 8, wherein said proposed set-up is transmitted over a communications medium to a remote workstation, said remote workstation comprising said computer instructions providing said series of predetermined steps for guiding a user to interactively evaluate said proposed set-up.

11. The method of claim 8, wherein the computer instructions further comprise instructions which allow a user to modify the proposed set-up during one or more of said predetermined steps, and wherein modifications made in any one of said one or more predetermined steps are carried over to subsequent steps in said series of predetermined steps.

12. The method of claim 8, wherein the computer instructions further comprise instructions which allow a user to navigate through said series of predetermined steps in any order desired by the user.

13. The method of claim 8, wherein the evaluation instructions further comprise

instructions which allow a user to compare the position of the teeth in the proposed set-up to associated bone and soft tissue in the craniofacial complex.

14. The method of claim 8, wherein said series of predetermined steps comprise the following evaluation steps of the proposed set-up:

1. checking said midline, said occlusal plane and reference objects, if any;
2. checking the lower arch form and the anterior/posterior (AP) positions of teeth in the lower arch;
3. checking the upper arch form and the AP position of the teeth in the upper arch;
4. checking the overbite and overjet;
5. checking intra-arch tooth alignment;
6. checking intra-arch tooth positions, rotations, contact points, marginal ridges, cusp tips, central grooves and cusp-fossa relations;
7. checking the torque values of at least some of the teeth of the upper and lower arches.
8. checking bite registration;
9. checking gingival architecture;
10. checking functional contact points; and
11. checking axial inclination of teeth.

15. The method of claim 14, wherein said computer instructions are designed to guide a user to follow steps 1-11 in numerical order, while simultaneously providing the user to navigate from any one of said steps to any other of said steps.

16. An orthodontic treatment planning workstation comprising a computing platform having a graphical user interface, a processor and a computer storage medium comprising:

said computer storage medium containing digitized records including patient image data, text data pertaining to the patient, and virtual models of said patient's dentition in (1) an initial state, and (2) a treatment set-up state; and

said computer storage further including a set of software instructions providing graphical user interface tools for access to said digitized records for planning orthodontic treatment of said patient, and a set of computer instructions providing a set of evaluation tools for a user to evaluate, with reference to said patient image data and text data, the treatment set-up state against boundary conditions for treatment of the patient and whether the tooth positions in the treatment set-up corresponds to the treatment goals for the patient.

17. The workstation of claim 16, wherein said evaluation tools further comprise automatic tooth feature identification tools enabling said user to automatically identify anatomical features of interest.

18. The workstation of claim 17, wherein said anatomical features comprise at least one of contact points, marginal ridges, cusp tips, cusp fossa, cuspal grooves, gingival margins and height of gingiva.

19. The workstation of claim 17, wherein said evaluation tools further comprise icon tools that enable said user to select particular tooth features for identification .

20. The workstation of claim 16, wherein said evaluation tools further comprise viewing

tools enabling said user to interactively manipulate said patient's virtual model in a two-dimensional view, a three-dimensional view, or a combination thereof.

21. The workstation of claim 20, wherein said viewing tools further enable said user to interactively examine and manipulate any point of interest on said patient's dentition virtual model, including individual teeth or a sub-set of teeth, in a two-dimensional view, a three-dimensional view, or a combination thereof.

22. The workstation of claim 20, wherein said viewing tools further enable said user to interactively flatten and manipulate a three-dimensional virtual model of the patient's dentition into a two-dimensional panoramic view and then convert said panoramic view back to a three-dimensional structure by conforming said panoramic view to a desired arch form.

23. The workstation of claim 16, wherein said evaluation tools further comprise illumination tools enabling said user to visualize otherwise hard to see features.

24. The workstation of claim 16, wherein said evaluation tools further comprise special visualization tools enabling said user to select, visualize and modify the patient's axial inclinations of crowns and roots of said virtual model of the patient's dentition in at least one of said states.

25. The workstation of claim 24, wherein said evaluation tools further comprise special tools enabling transfer of said patient's axial inclinations of crowns and roots from x-rays to

virtual model of said patient's dentition in at least one of said states.

26. The workstation of claim 16, wherein said evaluation tools further comprise automatic measurement tools for enabling said user in performing quantitative and qualitative analysis of said virtual model of the patient's dentition in at least one of said states using grids and point-to-point distances.

27. The workstation of claim 16, wherein said evaluation tools further comprise user selected measurement tools for enabling said user in performing quantitative and qualitative analysis using grids and point-to-point distances in 2D and 3D.

28. The workstation of claim 16, wherein said digitized records further comprise a normative database.

29. The workstation of claim 28, wherein said normative database enables said user to compare said initial state and said treatment set-up state against normative data.

30. The workstation of claim 28, wherein said normative database enables said user in performing radiographic and photographic analysis of said patient against normative data.

31. The workstation of claim 16, wherein said evaluation tools further comprise appliance evaluation tools enabling said user in interactively evaluate appliances including at least one of bracket type, prescription, geometry and position; arch wire geometry and configuration; or a combination thereof, or any other appliance proposed for treatment of the patient, either

prior to or following installation of said appliances on said patient's teeth.

32. The workstation of claim 31, wherein said appliance evaluation tools further enable said practitioner in interactively evaluating bracket positions, arch wire geometry, or a combination thereof.

33. The workstation of claim 16, wherein said evaluation tools further comprise standardized perspective views to interactively view said patient's dentition comprising frontal, saggital, or transverse view.

34. The workstation of claim 16, wherein said digitized records further comprise a library of virtual bracket sets enabling said user in evaluating a prescription for said treatment set-up state and said evaluation tools enabling said practitioner to make adjustments to said prescription by choosing an appropriate bracket from said library and/or changing the position of said bracket relative to a tooth .

35. The workstation of claim 16, wherein said evaluation tools enable comparisons of tooth positions in said patient's initial state relative to tooth positions in said treatment set-up state.

36. The workstation of claim 35, wherein said comparisons of tooth positions are done by viewing said intial state and proposed treatment set-up side-by-side.

37. The workstation of claim 35, wherein said comparisons are done by superimposition

of said states and providing visual indicia of the change of position from said initial state and said proposed treatment set-up state.

38. The workstation of claims 35 , wherein said comparisons of tooth positions are done automatically.

39. The workstation of claims 35, wherein said comparisons of tooth positions are done by comparison of position of user selected reference points in the virtual model of the patient's dentition.

40. A method for orthodontic evaluation facilitated by a treatment planning workstation comprising a computing platform having a graphical user interface, a processor and a computer storage medium comprising the steps of:

storing in said computer storage medium digitized records including image data, text data, and a virtual model of patient's dentition in an initial state and a treatment set-up state; and

providing in said computer storage a set of software instructions for graphical user interface tools for access to said digitized records for planning orthodontic treatment of said patient, and a set of computer instructions providing a set of evaluation tools for a user, wherein the predetermined steps comprise steps for 1) evaluation of said proposed set-up against boundary conditions for treatment of the patient, and 2) evaluation of whether the tooth positions in both arches, and the inter-arch relationship, of the proposed set-up correspond to the treatment goals for the patient; and wherein the predetermined steps permit said user to freely select the order in which the evaluation steps are conducted, and

wherein when the user selects each step the instructions provide task-specific graphical user interface tools guiding said user in performing evaluation tasks associated with each step; and evaluating said treatment set-up with the aid of said evaluation tools.

41. The method of claim 40, further comprising the step of providing tooth feature identification tools enabling said user to automatically visually identify anatomical features of interest.
42. The method of claim 41, wherein said anatomical features on include contact points, marginal ridges, cusp tips, cusp fossa, cuspal grooves, gingival margins, and height of gingiva.
43. The method of claim 41, further comprising the step of selecting an icon that enables a user to select a particular anatomical feature for identification
44. The method of claim 40, further comprising the step of providing viewing tools enabling said user to interactively examine and manipulate any point of interest on said patient's dentition virtual model, including individual teeth or a sub-set of teeth, in a two-dimensional view, a three-dimensional view, or a combination thereof.
45. The method of claim 44, further comprising the step of providing viewing tools enabling said user to interactively manipulate said patient's virtual model in a two-dimensional view, a three-dimensional view, or a combination thereof

46. The method of claim 44, wherein said viewing tools further enable said user to interactively flatten and manipulate a three-dimensional virtual model of the patient's dentition into a two-dimensional panoramic view and then convert said panoramic view back to a three-dimensional structure by conforming said panoramic view to a desired arch form.

47. The method of claim 40, further comprising the step of providing tools that simulate changes in illumination of said virtual model of the dentition to highlight otherwise hard to see features.

48. The method of claim 40, wherein said evaluation tools further comprise visualization tools enabling said user to select, visualize and modify the patient's axial inclinations of crowns and roots of said virtual model of the patient's dentition in at least one of said states.

49. The method of claim 48, wherein said evaluation tools further comprise tools enabling transfer of said patient's axial inclinations of crowns and roots from x-rays to said virtual model of said patient's dentition in at least one of said states.

50. The method of claim 40, wherein said evaluation tools further comprise automatic measurement tools for enabling said user in performing quantitative and qualitative analysis of said virtual model of the patient's dentition in at least one of said states using grids and point-to-point distances.

51. The method of claim 40, wherein said evaluation tools further comprise user selected measurement tools for enabling said user in performing quantitative and qualitative analysis using grids and point-to-point distances in 2D and 3D.

52. The method of claim 40, wherein said digitized records further comprise a normative database.

53. The method of claims 52, further comprising the step of comparing said initial state and said treatment set-up state against said normative data.

54. The method of claim 53, wherein said normative database enables said user in performing radiographic and photographic analysis of said patient against normative data.

55. The method of claim 40, further comprising the step of performing an appliance evaluation, wherein said user interactively evaluates appliances including at least one of bracket positions, arch wire geometry, or a combination thereof, or any other appliance fixture, either prior to or following installation of said appliances on said patient's teeth.

56. The method of claim 55, wherein said appliance evaluation step comprises interactively evaluating bracket positions, arch wire geometry, or a combination thereof.

57. The method of claim 40, wherein said evaluation further comprises providing

standardized perspective views to interactively view said patient's dentition comprising frontal, saggital, or transverse view.

58. The method of claim 40, wherein said digitized records further comprise a library of virtual bracket sets enabling said user in evaluating a prescription for said treatment set-up state and said evaluation tools enabling said practitioner to make adjustments to said prescription by choosing an appropriate bracket from said library and/or changing the position of said bracket relative to a tooth

59. The method of claim 40, wherein said evaluation tools enable comparisons of tooth positions in said patient's initial state relative to tooth positions in said treatment set-up state.

60. The method of claim 59, wherein said comparisons of tooth positions are done by viewing said initial state and proposed treatment set-up side-by-side

61. The method of claim 59, wherein said comparisons are done by superimposition of said states and providing visual indicia of the change of position from said initial state and said proposed treatment set-up state.

62. The method of claims 59, wherein said comparisons of tooth positions are done automatically..

63. The method of claims 59, wherein said comparisons of tooth positions are done by comparison of position of user selected reference points in the virtual model of the patient's dentition.

64. A method for orthodontic treatment evaluation for a patient facilitated by a treatment planning workstation comprising a computing platform having a graphical user interface, a processor and a computer storage medium comprising the steps of:

(a) storing in said computer storage medium digitized records pertaining to the patient including image data including 2d and 3D radiographic data, photographic and 3D data sets comprising virtual models of the patient's dentition in an initial state and a treatment set-up state;

(b) providing in said computer storage a set of software instructions for graphical user interface tools for access to said digitized records for treatment set-up evaluation of said patient, and a set of computer instructions providing a set of treatment evaluation tools for a user;

(c) with the aid of said evaluation tools, evaluating said patient's treatment set-up by performing the following steps:

1. checking said midline, said occlusal plane and reference objects, if any,
2. checking the lower arch form and the anterior/posterior (AP) positions of teeth in the lower arch;
3. checking the upper arch form and the AP position of the teeth in the upper arch;
4. checking the overbite and overjet;
5. checking intra-arch tooth alignment;
6. checking intra-arch tooth positions, rotations, contact points, marginal ridges, cusp tips, central grooves, and cusp-fossa relations;
7. checking the torque values of at least some of the teeth of the upper and lower arches;

8. checking bite registration;
9. checking gingival architecture;
10. checking functional contact points; and
11. checking axial inclination of teeth;

wherein steps (1) – (11) are done in the order listed above or in any other order selected by said user, and repeated as deemed necessary by said user and wherein steps (1) – (11) further include making comparisons and making modifications in the treatment set-up as and when necessary; and

(d) accepting said treatment set-up when results in steps (1) - (11) are acceptable; otherwise rejecting said treatment set-up.

65. The method of claim 64, further comprising the step of comparing said states against digital records for the patient, , said records comprising at least one of scan data, dentition model, intra-oral photographs, x-rays, panorex X-ray, and lateral ceph X-ray.

66. The method of claim 65, further comprising comparing said states against a dentition model derived from a physical model of the patient's dentition.

67. The method of claim 64, further comprising the steps of evaluating individual virtual teeth in at least one of the virtual models of the patient's dentition from a morphometric perspective and providing tools by which changes in the shape of the teeth may be simulated.

68. The method of claim 64, further comprising providing interactive and communications features in said workstation wherein one or more specialists may remotely

examine said patient's records and conduct a remote evaluation of said treatment set-up state..

69. The method of claim 64, wherein said patient's digitized records further include said patient's pre-processed dentition data and further comprising the steps comparing said patient's pre-processed dentition data with said patient's post-processed data.

70. The method of claims 69, wherein step (c) is further conducted using said patient's pre-processed data.

71. A method for orthodontic evaluation for appliances of a patient facilitated by a treatment planning workstation comprising a computing platform having a graphical user interface, a processor and a computer storage medium comprising the steps of:

storing in said computer storage medium digitized records including image data and virtual dentition model of patient's initial state and treatment set-up state, said medium further storing a virtual appliances;

providing in said computer storage a set of software instructions for graphical user interface tools for access to said digitized records for treatment set-up evaluation of said patient, and a set of computer instructions providing a set of treatment set-up evaluation tools for a user; and

with the aid of said treatment set-up evaluation tools evaluating appliances selected and positioned for use in achieving said treatment-set-up state.

72. The method of claim 71, wherein said appliances include brackets and arch wires,

said appliance images include images of said brackets and said arch wires, and said appliance libraries include templates and specifications of said brackets and said arch wires.

73. The method of claims 71, wherein said digitized records include said patient's scan data and photographs and further comprising the steps of evaluating said brackets against said bracket libraries, said scan data, and said photographs.

74. The method of claims 71 wherein said digitized records include said patient's scan data and photographs and further comprising the steps of evaluating said arch wires bends of 1<sup>st</sup> order, 2<sup>nd</sup> order, and 3<sup>rd</sup> order; evaluating said arch wires force systems, and evaluating said arch wires against standard templates from said appliance libraries.

75. The method of claims 73 , wherein said evaluation of said brackets and said arch wires is done iteratively and in combination of each other.

76. A method for orthodontic treatment set-up evaluation for individual teeth of a patient facilitated by a treatment planning workstation comprising a computing platform having a graphical user interface, a processor and a computer storage medium comprising the steps of:  
storing in said computer storage medium digitized records including image data and virtual models of patient's dentition in an initial state and treatment set-up state;  
providing in said computer storage a set of software instructions for graphical user interface tools for access to said digitized records for treatment set-up evaluation of said patient, and a set of computer instructions providing a set of treatment set-up evaluation tools for a user, said evaluation tools for evaluation of said proposed set-up state against boundary

conditions for treatment of the patient, the boundary conditions including at least a midline, an occlusal plane, a fixed reference object, and an arch form, and 2) evaluation of whether the tooth positions in both arches, and the inter-arch relationship, of the proposed set-up correspond to the treatment goals for the patient.; and

with the aid of said treatment set-up evaluation tools evaluating said patient's individual teeth in the treatment set-up state.

77. The method of claim 76, wherein said individual teeth include crown and root, and said patient's records include true anatomy images of said teeth and x-rays of said teeth's true roots or representations

78. The method of claim 77, further comprising the steps of defining the orientation of said individual teeth in the x, y, and z planes automatically or through selection by user from said patient's x-rays or from photographs or clinical examinations or through derivation from models by placing a reference line below and touching said crown away from said root, drawing an axis through said crown and said root in the center of said tooth, and measuring inclination of said axis relative to opposing tooth and relative to adjacent tooth, wherein the step of measuring inclination of said axis includes measuring said inclination in x, y, and z planes.

79. The method of claim 78, wherein the placement of said reference line and said axis are done automatically by said treatment planning workstation.

80. The method of claim 78, wherein the placement of said reference line and said axis

are selected by said practitioner or user.

81. The method of claim 78, wherein said individual teeth can be represented by reference lines for orientation viewed as points or as lines.

82. A method for orthodontic treatment set-up evaluation of a patient facilitated by a treatment planning workstation comprising a computing platform having a graphical user interface, a processor and a computer storage medium comprising the steps of:

storing in said computer storage medium digitized records including image data and virtual models of patient's dentition in an initial state and a treatment set-up state;

providing in said computer storage a set of software instructions for graphical user interface tools for access to said digitized records for treatment set-up evaluation of said patient, and a set of computer instructions providing a set of treatment set-up evaluation tools for a user; and

with the aid of said treatment set-up evaluation tools viewing said patient's dentition in a treatment set-up state in an occluded state; , and providing communications features in said workstation wherein multiple practitioners may evaluate said treatment set-up over the Internet.

83. The workstation of claim 16, wherein said memory further stores a virtual model of the patient's dentition during the course of treatment and a virtual model of the patient's dentition at the conclusion of treatment.

84. The method of claim 40, wherein said memory further stores a virtual model of the

patient's dentition during the course of treatment and a virtual model of the patient's dentition at the conclusion of treatment.

85. The method of claim 84, wherein the method further comprises the step of performing an evaluation of the treatment set-up using the evaluation tools based on the progress of treatment as indicated by the virtual model of the patient's dentition during the course of treatment.

86. The method of claim 84, wherein the method further comprises the step of performing an evaluation of the virtual model of the patient's dentition at the conclusion of treatment using the evaluation tools.